PETRA III synchrotron at DESY, Hamburg

HELMHOLTZ GEMEINSCHAFT

P10 Coherence Beamline User Guide

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1. Overview of the P10 Coherence Beamline

1.1. P10 scope

The Coherence Beamline P10 at the PETRA III synchrotron at DESY, Hamburg, is dedicated to experiments using coherent x-rays and to advance its major experimental techniques. These are x-ray photon correlation spectroscopy (XPCS) and coherent diffraction imaging (CDI).
XPCS is the x-ray analogue of dynamic light scattering (DLS) in the visible light range. By monitoring changes of 'speckled' diffraction pattern in the time domain, this technique allows it to study slow collective motions on length scales unobservable by visible light.
CDI is an x-ray imaging technique, which uses phase retrieval algorithms to reconstruct small objects from a coherent x-ray scattering pattern. Using advantages of x-rays, like e.g. element sensitivity or the high penetration depth, it is possible to image objects with a resolution of several tens of nanometers or to look at strain fields inside of nanocrystals.

The P10 beamline is located at a low beta section and takes advantage of the extreme brightness of the PETRA III storage ring. Currently, the PETRA III synchrotron is operating at 100 mA in top-up mode, which provides a coherent flux superior to all existing coherent beamlines at storage ring based x-ray sources (see Table below).

Coherent photon flux at P10:

$\Delta\lambda/\lambda$	ξ_l	$Flux_{coh}$	Energy
$6\cdot10^{-3}$ (pink beam, 1st harmonic)	0.025µm	$1.4\cdot10^{13}$	8keV
$1\cdot10^{-4}$ (Si(111))	1.5µm	$2.3\cdot10^{11}$	8keV
$3\cdot10^{-5}$ (Si(311))	5.0µm	$6\cdot10^{10}$	8keV
$2\cdot10^{-3}$ (pink beam, 3rd harmonic)	0.054µm	$1.4\cdot10^{12}$	12keV

1.2. P10 infrastructure

Overall layout of the P10 beamline is shown in Fig. 1. The source of x-rays for the P10 beamline is a 5m long U29 undulator located in the low-beta straight section of sector 7 of the PETRA III storage ring. The source size is $\sigma_h \times \sigma_v = 36 \times 6\mu m^2$. The beamline layout includes front-end slits, optics hutch (OH), experimental hutch 1 (EH1), experimental hutch 2 (EH2). Beamline infrastructure includes preparation laboratory (P-lab), mechanical workshop (M-lab), electronics workshop (E-lab) and a storage room (Fig. 2).

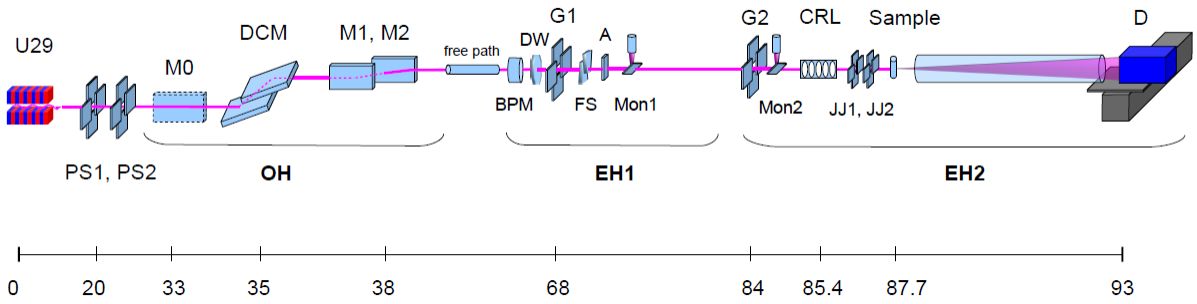


Fig. 1: P10 optical layout.

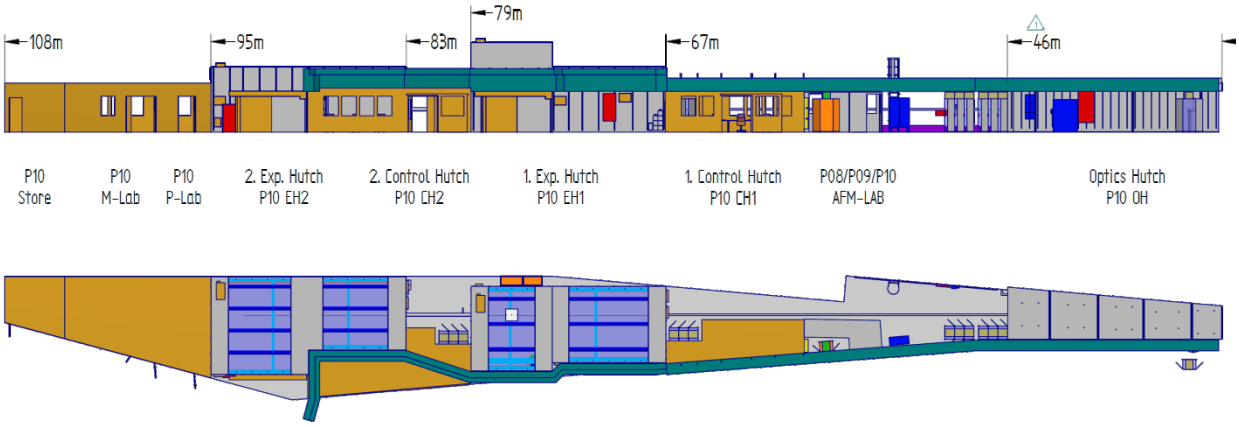


Fig. 2: P10 infrastructure.

1.2.1. Optics hutch

The Optics Hutch (OH) is situated 33-46 m from the middle of the straight section. There is some space available at the beginning of the optics hutch, which is reserved for a high heat load flat mirror to enable pink beam operation of the beamline. The standard PETRA III high heat load monochromator is the next major component (Fig. 3a). It is located at ~38 m and cooled by liquid nitrogen. Currently it is equipped with an independent Si(111) crystal pair (2.7-30.0keV) and an unpolished Si(111) channel-cut (7.0-17.0keV). In the future it is planned to replace the independent Si(111) crystal pair with a Si(311) channel-cut. Both channel-cuts will be polished. The channel-cut design offers a much higher angular stability of the beam at the price of reduced energy ranges and energy dependent exit offsets.

Next is a pair of flat (R > 100km) horizontally reflecting mirrors (Fig. 3b). The mirrors are coated with a Rhodium and a Platinum stripe to match the cutoff energy for higher energies to the experimental conditions. The mirrors are followed by the bremsstrahlung shield (often termed beamstop) in the optics hutch. The beamstop is a water-cooled Densimet collimator with holes for the pink beam (4mm diameter) and the monochromatic beam (4×11 mm^2). Both beams need to be offset from the white beam position by a minimum of 20 mm. A girder with several optical elements has been installed after the beamstop.

Site note: Currently the lowest reachable energy (~3.8keV) of the beamline is given by the minimum gap of the undulator of 9.8mm.

It is foreseen to install the lens changer in the optics hutch of P10 (installation is planned for the summer shutdown in 2013). The lens changer will be equipped with vertical focusing (1D) Beryllium lenses (Fig. 3c). A total of 6 different lens stacks will allow to match the horizontal and vertical transverse coherence length at a 2nd lens changer in the experimental hutch. This focusing scheme maximizes the available coherent flux for the experiment.

The 6 stacks will be equipped with the following lenses (number of lenses × radius of lens curvature [mm]):
1) 8 x 0.5mm
2) 4 x 0.5mm
3) 2 x 0.5mm
4) 1 x 0.5mm
5) 2 x 1.5mm
6) 1 x 1.5mm

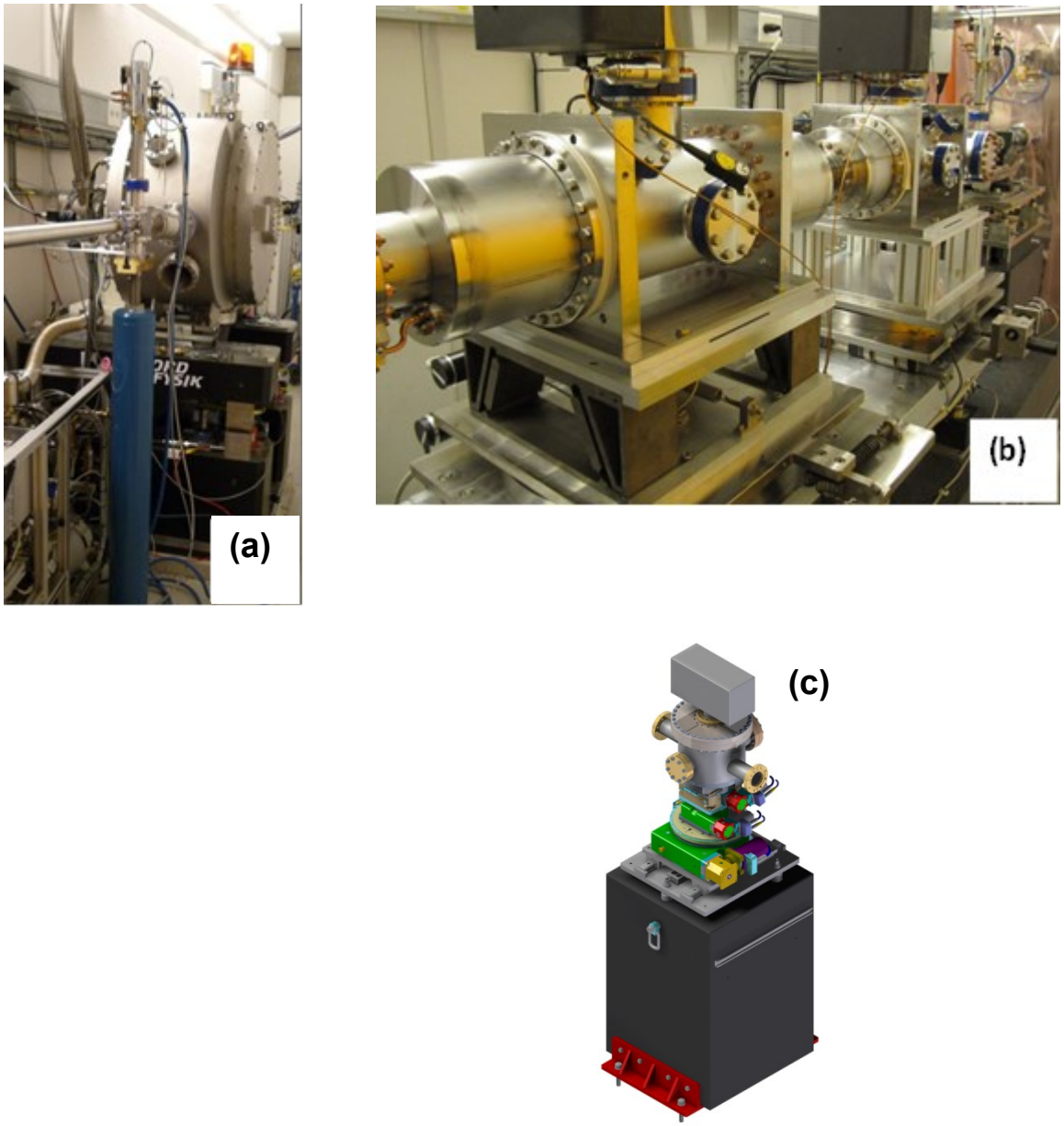


Fig. 3: (a) High heat load monochromator, (b) the mirror pair and (c) the 1D lens changer in the optics hutch of P10.

1.2.2. Experimental hutch 1

EH1 is a 12m long hutch situated 67-79m from the source. Figure 4 shows the experimental setups installed and foreseen in EH1. After some optical components (explained in more detail below), three different sample environments follow. First, a specialized setup for soft matter CDI/XPCS experiments with a sample-to-detector distance of ~ 20 m and relatively large beam sizes is installed. The accessible Q-range is limited ($Q < 2\times10^{-2}$Å^{-1} @ 8keV), but the reduced flux density can be beneficial for many soft matter systems. This sample environment is followed by the large 6-circle diffractometer, which is currently under commissioning. Finally, a rheology setup is installed which allows to conduct experiments in vertical scattering geometry.

The first 3m of the hutch are dedicated to house a set of shared optical components for the complete beamline (Fig. 5). The first element in EH1 is a combination of beam positioning monitor (BPM) by FMBOxford and diamond window situated on a granite block. The beam position is estimated from the backscattered intensity of 0.5 µm thick foils (Titanium or Nickel). The water cooled diamond window (5 mm diameter; 60µm thick) is connected to the BPM. This is the only window of the beamline separating the ring vacuum from the beamline vacuum.

These components are followed by an optical table that houses different optical components. EH2 contains an identical optical table to allow sharing of optical components between the experimental hutches. The first element is water cooled slit system operated in closed loop with a maximum opening of 10x10mm^2 and a resolution of 0.2 µm. The second element is a dual fast shutter system for 2D detectors. One system is based on amplified piezo actuators (similar to a design by Cedrat; ~1ms) and the second system is based on magnetic coupling (~30ms). This is followed by an absorber system and a retractable monitor unit to check the beam intensity.

Shared optical components in EH1

The first component in the first experimental hutch EH1 is a FMB Oxford beam positioning monitor (BPM). A water cooled diamond window (5 mm OD, 60 micron thickness) is connected downstream to the BPM. This device combination sits on a granite post and can be aligned (vertical and horizontal) to the beam using two Huber stages (Fig. 5a). The travel ranges allow to shift between 'pink' and 'monochromatic' beam options. It is possible to stabilize the beam position at the BPM using vertical and/or horizontal feedback programs.

The next object in EH1 is a 2.7m long optical table. This 5-axis table (Q-SYS) carries several shared components for the beamline . Situated on a granite spacer are a pink beam capable piezo driven slit system (Galil 1) with a nominal opening of 10 ×10 mm^2 as well as a fast shutter system, an absorber system and a first monitor unit (Fig. 5b).
The fast shutter unit houses two separate shutter systems: A water-cooled, piezo driven shutter system with ~1ms response time and a slower (~30ms) actuator driven shutter. The fast system has a small opening of ~0.7 mm and can be moved out of the beam by a linear translation.
The absorber consists of two linear translations. Each translations is equipped to hold 9 different absorbers. Currently the center position is left empty on both stages and two different materials are mounted on the different sides. One half holds Silver absorber for X-ray photon energies above 12 keV and the other half holds both sided polished thin Silicon crystals for lower X-ray energies.
Finally, the monitor unit is based on scattering of a thin Kapton foil under 45° in combination with a Cyberstar scintillator detector.

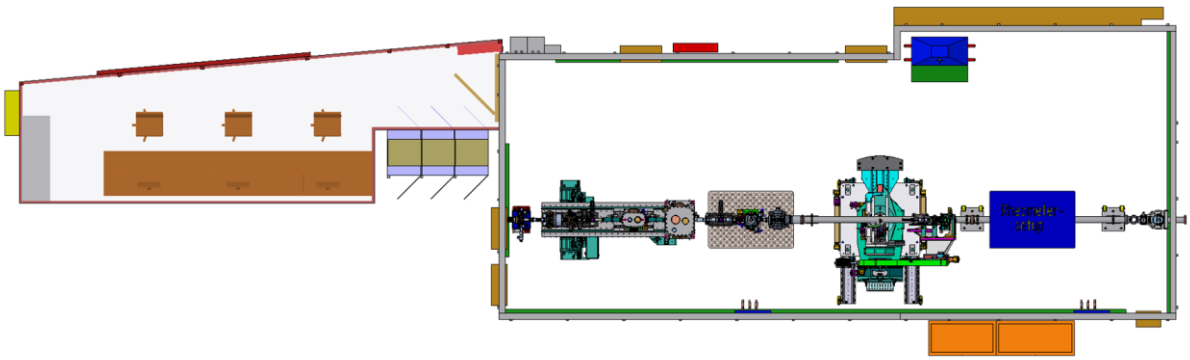


Fig. 4: Schematics of the 1st experimental hutch (EH1) and control hutch (CH1) at P10.

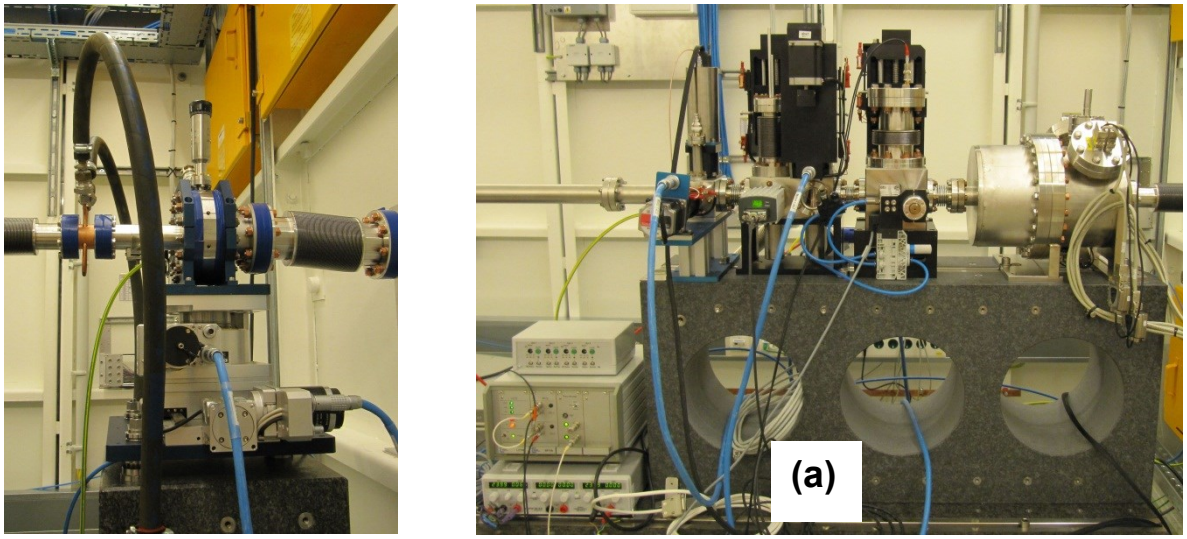


Fig. 5: Shared optical components in the EH1: (a) BPM; (b) slit system Galil 1, fast shutter, absorber unit and beam intensity monitor.

Soft matter CDI/XPCS setup of EH1

The setup for soft matter CDI/XPCS of EH1 (Fig. 6) is very similar to the standard CDI/XPCS setup in EH2. It is mounted on a 5-axis optical table from IDT. In front of the sample position, it features a pair of slit from JJ X-Ray (IB-C30-HV). These slits are ~700mm apart. The first slit defines the size of the X-ray beam and the second slit acts as a guard to suppress most of the slit scattering of the first slit. Between the slits, an in-vacuum (retractable) monitor unit is installed. The sample chamber is based on a DN100 (6" flange OD) UHV cube. The cube is mounted on a 4-axis Huber tower (X, Y, Z and RZ). The cube is fully vacuum integrated using DN (2.75" flange OD) bellows along the X-ray beam direction.

Multiple different sample inserts have been developed to be housed in the sample chamber (transmission and reflection setups, which are listed under EH2/Standard Setup/Sample Inserts). The sample position is followed by a DN100 (6" flange OD) 6-way cross. This 6-way cross allows e.g. to mount in-vacuum detector (e.g. diodes) as well as a vacuum pumping system. The last piece of the sample environment is a DN100 gate valve before the scattered signal is transported to the end of the hutch in a 4" ID tube. There the tube diameter increases to 8" ID and the beam transport continues to the detector stage in the 2nd experimental hutch. By using a detector position at the end of EH2, a sample-to-detector distance of ~20 m is possible.

The setup is modular and it is envisioned that components can be removed from the IDT 5-axis table to make room for more complicated experimental setups. The optical table is equipped with a 1.5×1.0 m^2 breadboard (mounting holes are M6 on a 25×25mm^2 grid). All optical tables at P10 are designed to have a 600 mm distance between X-ray beam and table top surface.

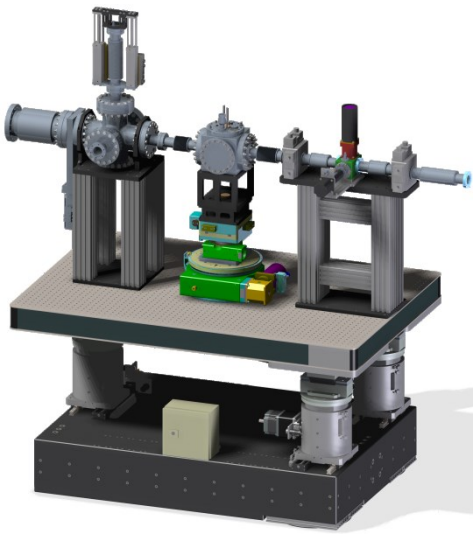


Fig. 6: Soft matter CDI/XPCS/USAXS setup of EH1.

Six-circle diffractometer

Experimental hutch EH1 is housing a large 6-circle Huber diffractometer (Fig. 7), which enables scattering/diffraction experiments at large scattering vectors Q. The diffractometer is very similar to a diffractometer installed in the first experimental hutch of P09. More detailed information will become available as soon as the first standard components have been adapted to the diffractometer environment.

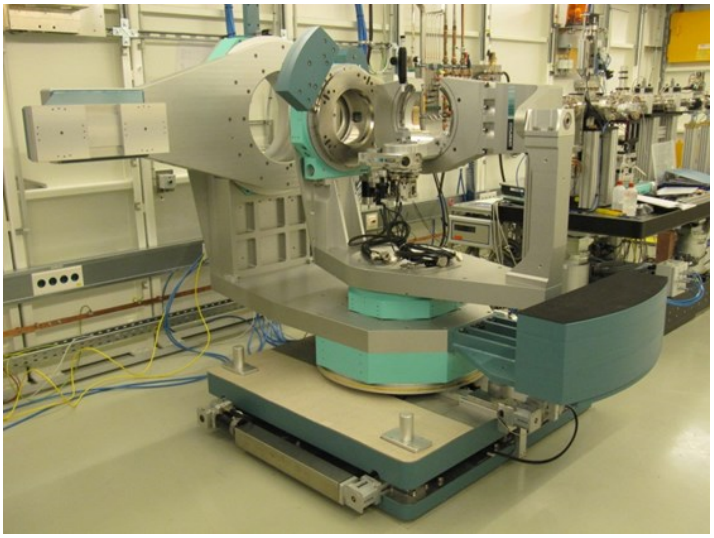


Fig. 7: Huber 6-circle diffractometer.

Rheology setup

Finally, the experimental hutch EH1 houses a rheology setup (Fig. 8). This setup allows to conduct experiments in vertical scattering geometry with a rheometer-to-detector distance of ~3 m using a HAAKE rheometer.

Fig. 8: RheoSAXS setup.

1.2.3. Experimental hutch 2

The second experimental hutch EH2 is located at 83-95m from the X-ray source (Fig. 9). It is home to the standard CDI/XPCS setup as well as to the holography setup. Most experiments performed at Coherence Beamline P10 have the sample located at ~87.8 m from the source. The standard setup and the holography setup are movable on air pads and can be easily exchanged. Both setups share an 5m long flight path as well as the motorized detector stage.

The optical table in EH2 carries a water cooled closed loop slit system followed by a retractable monitor device to define the beam direction as well as a micro-focusing lens changer (1D & 2D focusing capability) and a beam deflection unit (BDU) to enable studies on liquid surfaces.

General components

The first element in experimental hutch EH2 is a DN200 (8" tube ID) gate valve, which is not shown in the following. This page describes components which are situated on a 2.7m long optical table in EH2. The 5-axis table is similar to the optical table at the beginning of EH1. The table can be moved out of the beam to install a DN200 (8" tube ID) flight tube, which allows to have a sample in EH1 and use the detectors in EH2.
A piezo drien water-cooled slit system (Galil 2) followed by a monitor unit are sitting on a granite block at the start of the optical table in EH2 (Fig. 10a). The maximum nominal slit opening is 10x10 mm^2 and the resolution of the slit position is 0.2 microns. Similar to EH1, the monitor unit is based on scattering of a thin Kapton foil under 45° in combination with a Cyberstar scintillator detector.
The beamline uses Beryllium lenses to reach focal spot sizes between 3-5 microns in both, vertical and horizontal, direction. The lens changer (transfocator design) is equipped with 12 stacks of interchangeable Beryllium lenses, which allows to have the correct lens combination for the desired focal distances (of several meter) and for X-ray energies between 5-18 keV (Fig. 10b). A Matlab macro can be used to calculate the best lens combination and best lens-to-sample distance for the chosen X-ray energy.
The beamline has developed a beam deflection unit (BDU). The BDU uses two Ge(111) crystals to slightly tilt the beam downwards (Fig. 10c). This enables studies of liquid surfaces in grazing incidence conditions (i.e. no full reflectivities up to large angles, but enough to reach incidence angles of up to 2x the critical angle of most liquids). Details on the construction can be found in the diploma thesis of Milenko Prodan and the apprenticeship report of Sergej Bondarenko (both are in German).

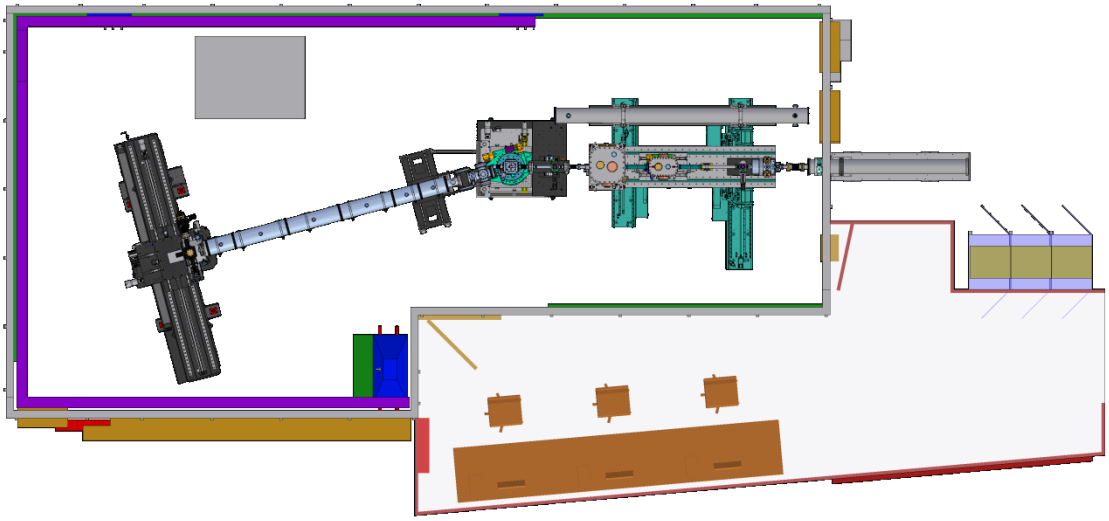
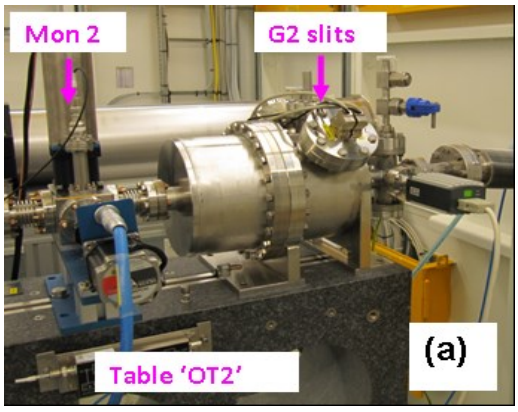
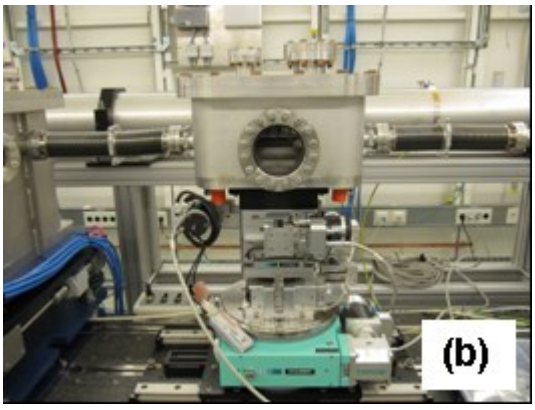


Fig. 9: Schematic view of the 2nd experimental hutch with control hutch.





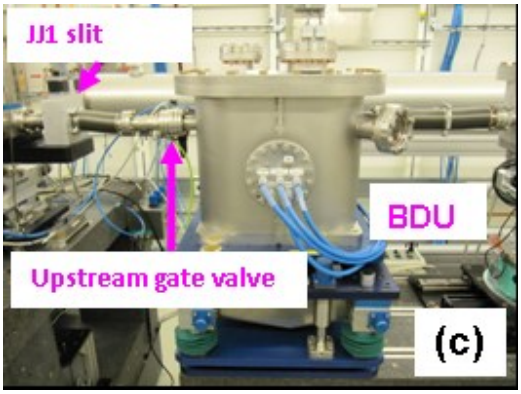


Fig. 10: Optical elements on 'OT2' of EH2:
(a) pink beam slits 'Galil 2',
(b) CRL transfocator,
(c) beam deflection unit.

Standard CDI/XPCS setup at EH2

The standard CDI/XPCS setup in EH2 is based on a 2-circle Huber diffractometer in horizontal geometry (Fig. 11a). This diffractometer is mounted on a granite support and can be moved out of the beam path on air pads. The diffractometer is based on a combination of a Huber 440 and 430 goniometer sitting on a YZ translation. For most experiments the 440 goniometer is used as the rotational bearing for the 5 m long detector arm. On top of the goniometers a tower of Huber stages (170×170mm^2 size) is mounted. In the typical configuration it offers XYZ translations (XY: Huber 5102.20; Z: Huber 5103.A20-40) as well as a 2-circle segment (Huber 5203.20) for rotations around X & Y. A DN100 (6" flange OD) vacuum cube is used as the standard cell for the sample environment. Examples for different sample cell inserts are displayed when clicking on the navigation button (left side).

For experiments in SAXS geometry, the sample cell is fully vacuum integrated. It is connected along the X-ray beam direction with DN40 (2.75" Flange OD) bellows. Upstream of the sample environment sits a pair of JJ X-Ray slits (IB-C30-HV) on a Huber YZ stage. Between the slits is a vacuum integrated monitor unit. Downstream of the sample environment a 6-way cross (4" tube ID) followed by a DN100 gate valve connects the sample region via a 5 m long flight path to the detector region (Fig. 11b).

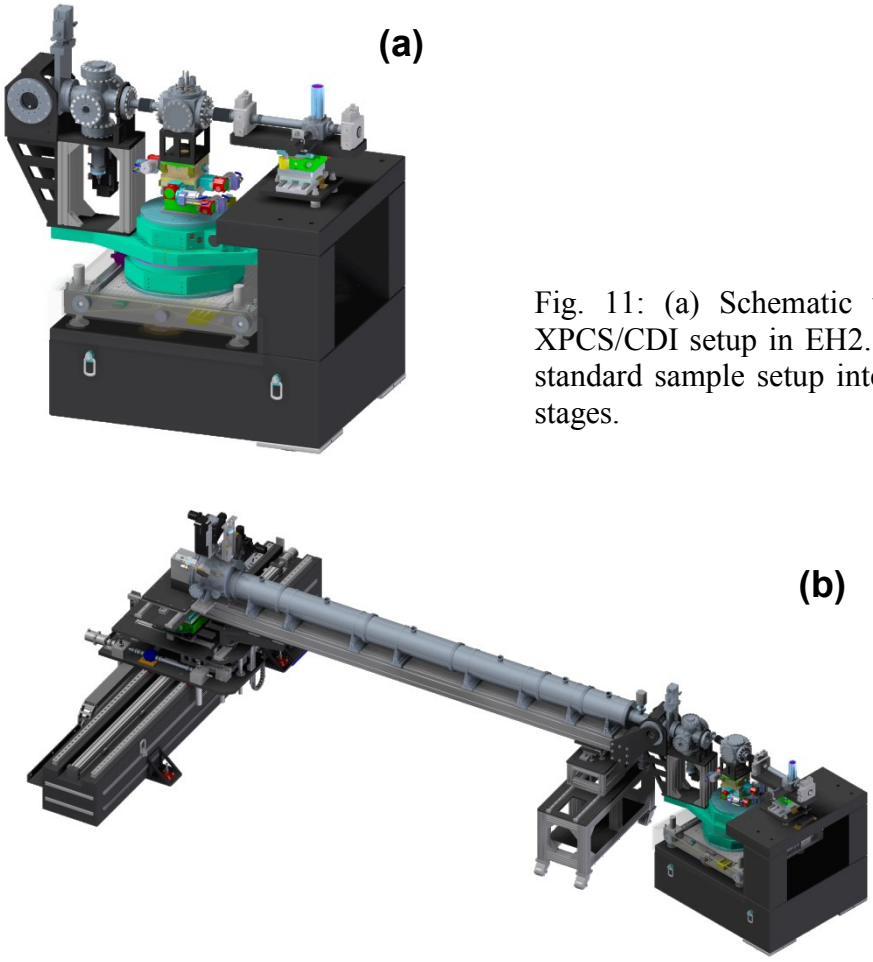


Fig. 11: (a) Schematic view of the standard XPCS/CDI setup in EH2. (b) Schematics of the standard sample setup integrated to the detector stages.

Sample inserts

The main idea of using a DN100 vacuum cube as an experimental chamber is the possibility to easily change between different experimental conditions. P10 has developed a set of standard sample inserts, but it should be easily possible to design a sample insert for almost any arbitrary experimental condition. Additional possibilities are e.g. a stress-strain insert. Fig. 12 shows the drawings of currently available sample inserts.

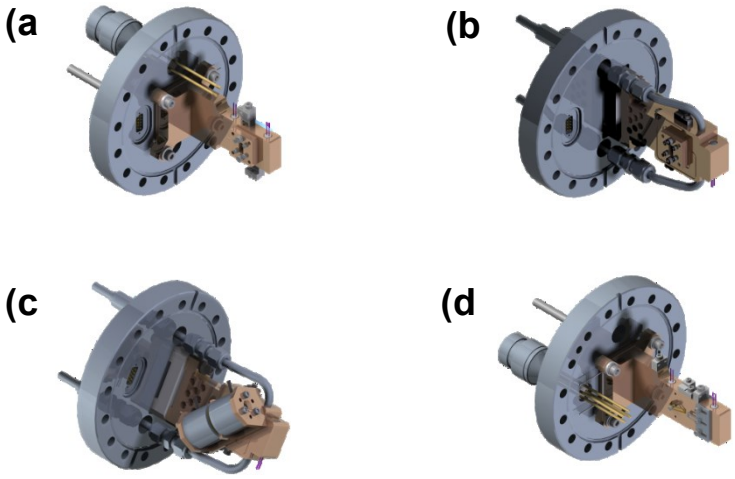


Fig. 12: (a) The transmission sample insert. This insert allows to study samples in vacuum sealed capillaries at temperatures in between 0 - 200 °C.
(b) The low temperature transmission sample insert. This insert covers a temperature range in between -150 - 50 °C.
(c) The low temperature insert with an additional holder for small magnetic fields. The holder is based on electromagnets and produces variable fields up to ~0.1 T.
(d) A sample insert for reflection experiments in a temperature range from 0 - 200 °C.

Nanofocusing setup at P10

The group of Prof. T. Salditt of University of Göttingen designed and installed the experimental setup GINIX for holographic imaging at P10. The setup is placed on a 5-axis table (IDT). This table is movable on air pads and can be exchanged with the standard CDI/XPCS setup. Further details can be found in

1) Kalbfleisch, S., Neubauer, H., Krüger, S. P., Bartels, M., Osterhoff, M., Mai, D. D., Giewekemeyer, K., Hartmann, B., Sprung, M. & Salditt, T. (2011). *AIP Conf. Proc.* **1365**, 96-99.

2) Kalbfleisch, S. (2012). PhD thesis, Georg-August-Universität Göttingen, Germany.

Flight path and detector stage

The detector stage in experimental hutch EH2 of P10 is based on a 3.5 m long translation mounted on a granite block at the end of the experimental hutch (Fig. 13). The granite block is rotated by ~15° from the perpendicular direction to the beam. This setup allows to rotate the 5m long flight path and detectors around the sample position by ~30 degrees in the horizontal direction, which makes it possible to perform coherent scattering experiments at large Q values (~2 $Å^{-1}$ @ 8keV). A set of different detectors currently in use at P10 is described in section 3.

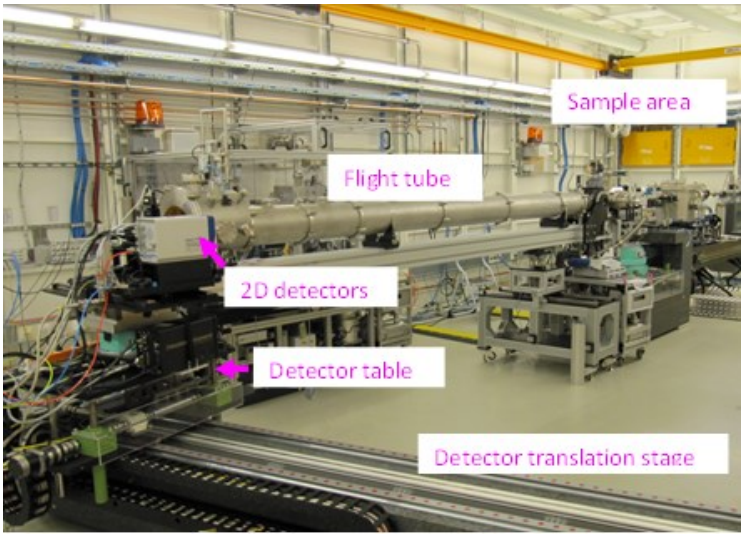


Fig. 13: (a) View of the standard CDI/XPCS setup in EH2.

1.2.4 Support laboratories

Coherence Beamline P10 has three supporting laboratories: A mechanical laboratory (P10-MLab), an electronic laboratory (P10-ELab) and a sample preparation laboratory (P10-PLab). The names are an indicator of their main use.

The mechanical laboratory is dedicated to preassembling of sample environments, testing of vacuum windows and whatever tasks seems to fit. It is equipped with a small working bench, a water sink, supply of compressed air and some standard gases as well as cooling water.

The electronic laboratory is equipped with an additional electronic rack, which includes a VME and a NIM crate. This allows testing of new motor stages or detectors offline from the beamline. Again, cooling water, compressed air and standard gases are available.

The sample preparation laboratory is not a full chemical laboratory, but it allows simple tasks with harmless chemicals to be undertaken (e.g. cleaning of vacuum components). Access to a fully equipped chemical laboratory can be obtained via the DOOR system.

2. Starting the Experiment

2.1. Hutch search procedure

All areas of a beamline at PETRA III need to be searched before the x-ray beam can be turned on. The purpose of the search is to make sure that nobody is inside of the area when the x-ray beam is on. The interlock system of PETRA III has developed a method for this purpose and this method will be described here:

One user has to start the search procedure by placing a valid DACHS card over the DACHS card reader (Fig. 14) near the "main" door (!!All other doors and gates need to be closed in advance!!). This starts a warning message for the area and activates the light barrier (which acts as a person counter) and the first search button (a green button near the door) inside the area lights up. The user proceeds by entering the hutch, searching the hutch and doing so pressing all necessary search buttons (green buttons). After the user is finished with the search the user returns to the hutch door and presses the yellow button near the door to deactivate the light barrier for 5 seconds. Only then the user is able to leave the area and to close the door. If the user has succeeded to follow this procedure an orange light will come up near the door. The search is finished by pressing the last "Final search" green button outside of the area followed by placing the DACHS card over the DACHS card terminal again. An additional red light will show up on top of the orange light. The warning message will sound for a short moment before the "Permit Beam Operation" button gets enabled on the Interlock Control System web page. Pressing this button locks the doors and enables the "Open BS" button on the area panel.

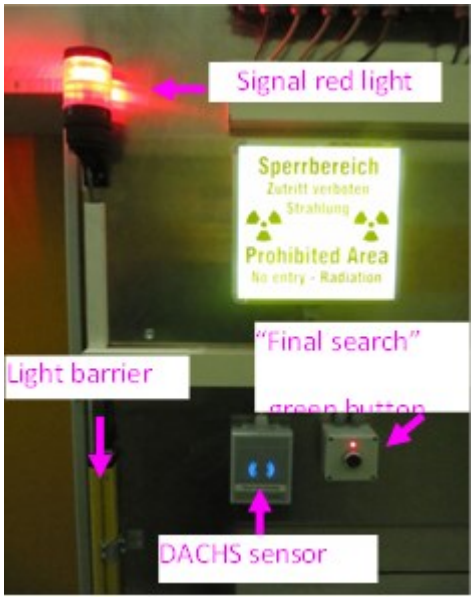


Fig. 14: Interlock panel of P10 beamline (OH).

2.2. The interlock control system

The interlock control system is controlled by a web based interface. It can be found on the 1st tap of the Firefox P10 homepage of the control computers (haspp10e1 & haspp10e2). The link is: http://ics/index.php.

The web site is divided into two parts. The top part indicates the layout of the beamline. In the case of P10 it shows three areas (optics hutch, experimental hutch 1 and experimental hutch 2) divided by beamshutters. The lower panel shows the current status of a particular area (in this case Area 3, which is the experimental hutch 2). Clicking at the areas switches the panels. At the moment of the screen shot (Fig. 15) the x-ray beam was passing into the end station of P10.

To close the shutter and to enter the hutch, it is necessary to

a) press "Close BS 10.2",
b) press "G 10.3 Cancel Beam Permission" and
c) unlock the doors by pressing "Break door interlock G10.3".

Each of these actions needs to be confirmed by pressing "Ok". Before the shutter can be reopened the hutch needs to be searched (see 2.1.). After the warning message has finished the "G10.3 Permit Beam Operation" button needs to be pressed (this locks the doors) before the shutter can be opened by pressing "Open BS10.2".

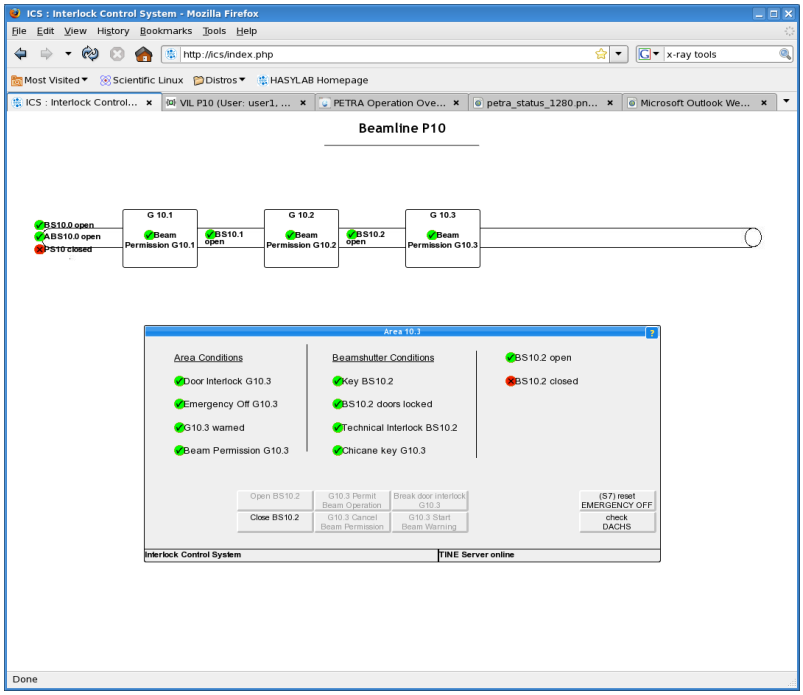


Fig. 15: Screenshot of the web interface of P10 interlock control system.

2.3. Coordinate system at P10

P10 uses a right handed coordinate system, which is defined by the x-ray beam direction. The 'X' axis is parallel to the beam direction, going to positive values away from the x-ray source. The 'Y' axis is perpendicular to the beam direction ('X') lying horizontal. The 'Y' axis goes to positive values outboard from electron/positron accelerator ring. The 'Z' axis is perpendicular to the beam direction ('X') standing vertical. The 'Z' axis goes to positive values from the floor up.

Standard translation are called '..._X', '..._Y' & '..._Z'. The names is derived by starting with a descriptive part followed by an underscore and the following letter ('X', 'Y' or 'Z') indicates along which axis the translation is.

Standard rotation are called '..._RX', '..._RY' & '..._RZ'. The name is derived by starting with a descriptive part followed by an underscore. The 'R' indicates that it is a rotation and the following letter ('X', 'Y' or 'Z') indicates which axis the rotation turns around. The sense of the positional values are defined due to the fact that all rotations are right-handed (i.e. use the 'right hand rule' from your undergraduate physics course).

Exceptions to this system will be explained on a case by case basis.

2.4. Preparing the beam

After the synchrotron beam is provided by the machine division (the message on the PETRA III status panel has turned to ‘User Experiments’) one can proceed to start the experiment as follows.

- First, all beamline hutches (optics hutch, experimental hutch 1, experimental hutch 2) have to be set up (see §2.1).

- Next, one should close the undulator gap to the required value (16.3 mm for photon energy of E=8 keV). This can be done by moving the virtual motor ‘UNDULATOR’ in <ONLINE> GUI to the desired energy in [eV] (Note, that for energies above 12 keV one has to use 3rd harmonic of an undulator, i.e. energy divided by a factor of 3 has to be applied). The process of closing the undulator from ‘opened’ state to a ‘closed’ state may take several minutes. During this time it is highly recommended not to launch any other commands in <online> session.

- The motor ‘FMBEnergy’ (Bragg angle of double-crystal monochromator) has to be also set to the required photon energy in eV.

- After closing the undulator gap one should wait for about 15 minutes until the monochromator optics reaches the thermally stable state. After that one can open safety shutter(s). Namely, all shutters in interlock GUI (Fig.

15, panel 10.1 – optics hutch, panel 10.2 – EH1, panel 10.3 – EH2) have to be opened.

- The sizes of Galil slits G1 and G2 should be checked. These slits define an optical axis for the whole beamline path and only horizontal and vertical gap values need to be set (center positions should remain). Usually the G1 is set to 0.6×0.6 mm^2 and the G2 – to 0.3×0.3 mm^2.

- If the undulator gap was set to a new setting it has to be scanned anew. The 'UNDULATOR' virtual motor has to be scanned in a relevant range and set to a peak position.

- In case the beamline was previously aligned, there should be already beam intensity counted by the Cyberstar beam monitors in EH1 and EH2. Usual command is

  >osh; count; csh.

  This command opens fast shutter, counts the intensity for 1 s and closes fast shutter.

- Fine alignment of the monochromator is executed by the virtual motor 'XTAL2_PITCH' which should be scanned in a proper range (the stored setting should normally be correct; in case of doubt please ask the local contact). After a scan is finished the motor has to be set to a center-of-mass position.

- Next, the 2nd mirror should be scanned using the motor 'MIR2RZ' which is a pitch angle for this mirror (default range should be right, otherwise a range of ±0.002 deg. is sufficient). The position should be set to a center-of-mass value.

- After scanning the 2nd mirror, a monochromator pitch scan should be repeated. After this is done the optical alignment is mainly completed and the vertical beam position stabilisation should be turned on by launching the python script 'bpmcontrol.py' located at the /beamline/macros/python/ folder on the experimental control PC (haspp10e1 or haspp10e2 for experiments carried out at the EH1 or EH2, correspondingly). Note that for repeating monochromator pitch the bpmcontrol.py script has to disabled first.

- Further steps concern the alignment of JJ slits, focusing optics, beamstops, detector and a sample, which will be described further in the User Guide.

2.5. Sample mounting

The procedure of mounting/changing the sample depends on the type of executed experiment. For in-vacuum sample mounting the first step is to vent the sample area. After the venting is done, the sample can be changed. The last step is evacuating of the sample cell.

How to vent and pump the sample area

The sample cell is connected to a turbo pump stage and two gate valves can be used to separate the sample from the flight path before and after the sample. **To safely change a sample** several steps are necessary and described here:

1) Vent the sample cell:

1) Close both gate vales by turning the 'Output' of the HAMEG power supply off
2) Press 'Stop' on the turbo pump touch panel
3) Press 'Open Vent' on the turbo pump touch panel
4) Open the manual vent valve near the sample cell slightly (20-30mbar on P3) and wait for the turbo pump to spin down ~10.000 rpm
5) Fully open the manual valve and wait till the pressure is equalized
6) Remove the sample insert and change your sample

2) Pump the sample cell:

1) Remount the sample cell insert
2) Close the manual vent valve near the sample cell
3) Press 'Close Vent' on the turbo pump touch panel
4) Press 'Start' on the turbo pump touch panel
5) Wait until the pressure sensor P3 reads a pressure < 1e-03 mbar
6) Open both gate valves by turning the 'Output' of the HAMEG power supply on

Now you are ready to search the hutch and start measuring your new samples.

2.6. JJ X-ray slits calibration

The paragraph describes a procedure to calibrate the JJ X-Ray slits (pair of slits in front of a sample, Fig. 10a) on a micro meter level. The first step for a rough alignment should be to look at the beam with the x-ray eye. Use the macro '*det xray'* The user should close the slit blades one by one roughly centered over the beam on the x-ray eye. This way the user should produce a small square beam on the x-ray eye display. Beam sizes smaller than 100 microns by 100 microns can easily produced this way.

Now change to the Cyberstar detector using the '*det cbs'* macro (currently Si diode inside the flight tube is used instead, command > diode in). Now the user should close the slit by moving the top blade and perform an absolute scan (~5 micron step size) towards positive values. In this direction the top blade has no backslash. The scan should be flat in the beginning (close position) and start to increase linearly at some point. After the scan is finished return to this turning point and perform a fine scan (1 micron step size) around this position. The turning point found during this fine scan should be used to set both the top and the bottom blade to zero. Now the slit should be opened to ~50micrometers in the vertical direction and the procedure should be repeated in the horizontal direction. Here the slit needs to be closed by the left blade. The left blade in than scan in positive direction without backslash as in the vertical direction.

Once the slit size is defined in both direction the slit center can be scanned. The slit are setup in a way that the center scans are performed without backslash. Once the center are found the positions of all four blades should be reset.

The following example sequence of commands serves to adjust JJ X-ray slits (SLT1, SLT2) using Si diode.

One of JJ X-ray slits, for instance SLT1, has to be fully opened (> moveslit 1 2 0 2 0) while the other, SLT2, is getting adjusted. All the positions mentioned further are in mm. Diode has to be in (> diode in).

1) Adjust SLT2 horizontally by setting its size to 0.5 mm and check transmitted intensity:

   > moveslit 2 0.5 0 2 0; count

   Make slit gap smaller until the transmitted intesity starts to decrease; at this point one should roughly adjust the horizontal center (SLT, cx).

   Slit down horizontal gap to 0.1:

   > moveslit 2 0.1 0 2 0

   and do scan of horizontal center:

   ONLINE GUI: 'Scans' → 'Slit' → SLT2 → 'cx' ;

   the range is 0.8 , number of points 41.

2) After the scan has finished, go to the center of the scanned maximum. Next we scan the horizontal gap (SLT2 → dx) in a range -0.02 … 0.02 (note: JJ slits are made such that negative gaps are possible while the blades can go behind each other without clashing). The last scan should

have a step-function profile. The point where intensity starts to linearly increase is the actual 'zero' of horizontal gap. To calibrate both 'Left' and 'Right' blade positions one selects 'Properties' by right-click, then puts 'Register' to zero followed by 'Apply', and then one puts 'Position' to zero also followed by 'Apply'. OK, with that horizontal gap is calibrated.

3) Now the vertical slit has to be adjusted. For that we open horizontal gap to 0.4 and repeat steps 1)-3) for the vertical center (‘cy’) and gap (‘dy’).

To adjust the first slit SLT1 one has to open the SLT2 (> moveslit 2 2 0 2 0) and follow steps 1) - 4).

2.7. CRL transfocator alignment

The CRL x-ray transfocator based on beryllium CRLs is installed at the EH2 at a distance of 86.1 m from a source. The CRLs with different curvature radii (50 to 1000 μm) are grouped in 12 stacks. The first 4 stacks contain 1D lenses and the other 8 stacks contain 2D lenses. There are in total 2^{12}=4096 possible lens combinations. In order to select the best combination for a given photon energy and image distance all possible combinations should be scrolled. For this purpose a Matlab script was written which calculates the correct lens combination as well as the optical parameters of a focused beam (offset distance, focal spot size, efficiency, gain and depth of focus). The script is available on the Windows analysis PC of EH2 control hutch. Start Matlab and browse to the directory 'C:\Matlab\tools'. The script is called 'P10lens_v2' and expects two input parameters, the x-ray energy in keV and the distance from lens center to sample in meters. At the standard lens position this distance is 1.574 m. The Matlab call 'P10lens_v2(8.0, 1.574)' generates the following output:

```
ans =
       bestcombi: 768
       bestbinary: [0 0 0 0 0 0 0 0 1 1 0 0]
            bgoal: 1.5740
             dist: -0.0489
            bfinal: 1.6229
        deltadist: -1.5616e-005
     verticalsize: 2.5189e-007
  horizontalsize: 1.5113e-006
  bestefficiency: 78.2624
       bestgain: 3.2894e+005
        nstacks: 2
         DOF_v: 0.1045
         DOF_h: 0.1045
     v_size_diff: 3.0788e-006
     h_size_diff: 3.4204e-006
```

Note: all the output distances are in meters.

For transfocator alignment the following parameters are important:

- *'bestcombi'*. This parameter is the value needed to select the correct CRL stack combination. These stacks are moved into the beam by typing the command:

  online> mva ehcrl *bestcombi*

  The lens is moved out of the beam by typing ' online> mva ehcrl 0'.

- *'dist'*. This value describes an offset value for the motor 'ecrlx2'. This motor moves the whole lens tower along the beam direction to bring the focal spot to the sample. The command is

  online> mva ecrlx2 *dist*

  Here *dist* is an offset distance in mm.

During the transfocator alignment both JJ1 and JJ2 slits should be opened (1 × 1 mm²). Alignment of the transfocator is done by scanning the whole device in vertical and horizontal directions perpendicular to the beam (G2 should be set to 0.2×0.2 mm²). Corresponding motors ‘ecrly’ and ‘ecrlz’ should be scanned in a relevant range (± 0.5 mm). Additionally the two tilts, ‘ecrlry’ and ‘ecrlrz’ have to be used for final alignment of the transfocator axis (which should be parallel to the beam).

Once these commands are executed, the G2 slit size should be set to 100 – 200 μm vertically and 75 – 100 μm horizontally (a trade-off opening of 150(V) × 75(H) μm² provides high spatial coherence at optimal coherent flux in a focused beam). In addition the user can close the JJ2 slit to about 0.05 x 0.05 mm² around the beam for reduction of a background scattering.

3. Detectors at P10

The Coherence beamline P10 has several different detectors in use and it is possible to reserve additional specialized detectors via the DESY detector pool:

- Pilatus 300K detector (Dectris),
  487x619 pixels,
  Pixel size of 172×172 μm^2.

- A Maxipix 2x2 detector (ESRF) is often is use at P10.
  516x516 pixels,
  Pixel size of 55×55 μm^2.

- As the 'work horse' 2D detector for XPCS / CDI experiments a PI-LCX detector (Princeton Instruments) is available. This slow direct illumination CCD with a 20×20 μm^2 pixel size and 1340×1300 pixels has been used intensively at coherence beamlines around the world.

- A Mythen 1K detector (PSI) is used as a fast 1D detector at P10, having 1280 strips.

- As a point detector an avalanche photo diode (ESRF) is available in combination with an hardware autocorrelator (Correlator.com).

3.1. PILATUS 300K

The PILATUS 300K detector is a 2D detector (developed by PSI and sold by Dectris) with a pixel size of 172x172μm^2, 487x619 pixel active area, 20-bit/pixel dynamic range and readout time of 7 ms. The quantum efficiency is 91% at 5.4 keV, 96% at 8 keV and 37% at 17.5 keV.

To start operating the Pilatus one has to proceed as follows:

1) From the experimental terminal in EH2

   p10user@haspp10e2:~$> ssh –l det haspp10pilatus

   > cd p2_det

   > runtvx

2) Start Pilatus Tango server ‘Pilatus/P10E2’ from the Astor panel

3) Make sure the detector is ‘active’ (uncommented) in the online.xml file

4) restart <online> GUI

5) Setup working directory
   <online> p300setup "*directory*" "*name_of_file*" 1
6) Use 'p300take' or 'p300series' commands to record images.

To start the P10 image viewer :

1) p10user@haspp10e2:~$> cd /beamline/matlabmacros/

   p10user@haspp10e2:~$> cp P10show2_pilatus300K.ini P10show2.ini

2) Start image viewer GUI by double-clicking the desktop shortcut 'Show Pilatus'

3) Enter relevant file path and prefix; 'Update' button serves to view a selected image.

3.2. MAXIPIX 2x2

The Maxipix detector in 2x2 configuration is a 2D detector developed at ESRF which has a pixel size of 55x55µm^2, 516x516 px^2 (28.4x28.4 mm^2) active area, dynamic range (count rate) of 100000 cps/pixel at 10% dead time and maximum frame rate of 350 Hz (0.3 ms readout). The quantum efficiency is 100% at 8 keV, 68% at 15 keV and 37% at 20 keV.

In the following it is explained how the Maxipix detector is implemented at the P10 beamline.

1) A 'ssh' connection to the Maxipix control computer needs to be established via:

> ssh opid00@mpxdesy2.desy.de

There exists an auto login from the experimental control computers ('haspp10e1' or 'haspp10e2'). Please check at this point of the network storage of P10 is mounted by testing the command 'cd /data'.

2) The program 'Dserver1' (5x1) or 'Dserver2' (2x2) needs to be started from the command line on the Maxipix computer. Once these steps are finished, the Maxipix device definitions can be activated in the 'online.xml' file and 'Online -tki' can be called on the experimental control computer ('haspp10e1' or 'haspp10e2').

The Maxipix detector can now be controlled from 'Online' in a variety of ways:

a) A widget has been created on the 'Online TKI Window' under 'Misc'.
b) Several Perl scripts are available to take a single image or a time series of images.
c) The Maxipix detector has been implemented as virtual counter.
d) The Maxipix detector has been implemented into the XPCS measurement scripts.

There are typical three Perl scripts (...setup, ...series and ...take) for 2D detector operation at the P10 beamline. These can be called from the command line in the following way:

1) 'max22setup *"/network storage directory/" "filenamestart_" firstframenumber*'
2) 'max22series *nframes exposuretime*'
3) 'max22take *exposuretime*'

Note: The Tango server for the Maxipix detector loads by default an incomplete configuration and it is advisable to run the setup script ('max51setup' or 'max22setup') once at startup to define all necessary parameters.

3.3. PI-LCX

The LCX detector is a CCD detector (Princeton Instruments) with a pixel size of 20x20µm^2 , 1340x1300 pixel active area, 16-bit dynamic range (effective 5-6 bit dynamic range) and readout time about 1.7s. The quantum efficiency is 75% at 5 keV, 50% at 8 keV and <5% at 12 keV.

The operation of the LCX camera from Online/Tango is not straight forward. The momentary solution communicates via a Perl server script with the Roper Scientific Winview software. This communication is one-sided, meaning that Winview is not providing any information (output) about its status. This means, that the Tango/Online control has to be very careful. Any error message in Winview will cause severe problems which will need several steps to recover (up to restart Winview + Perl Server and Tango Server!).

The WinView program is installed on 'haso052lcx.desy.de' and the account 'lcxuser' should be used. Before launching the Winview software (shortcuts can be found on the desktop and the quick launch toolbar), the PI-LCX camera should be connected to the ST133 camera controller, which can be sub-sequentially turned on. The next step involves mounting the network storage. The network storage drive is mounted as disk Y:\. It must be mounted from the p10user!

After launching the Winview software the cooling for the CCD chip should be turned on and be set to -40degC. This can be done in Winview under 'Setup/Detector temperature'. Also, the image orientation should be set under 'Setup/Hardware' on the display tab. The 'Reverse' and 'Flip' flag should be set.

Once these steps are finished the Perl server program 'lcx_xpcs_server.pl' must be launched by clicking the shortcut 'StartPerlServer.bat' (again on the desktop or on the quick launch toolbar). The Perl server program as well as the other Perl scripts can be found in 'D:\Perl\'. The file 'StartPixisPerlServer.bat' should be used for the PIXIS detector.

Now all necessary steps on 'haso052lcx' are finished and the user should restart the Tango Server 'LCXCamera/P10E2' to re-establish the communications.

The Perl Server can read and write the following attributes, 1) SavingPath, 2) FileNameStart, 3) FirstFrame, 4) NumFrames, 5) ExpTime, 6) DelayTime as well as the following commands 1) Go and 2) Status.

The 'Go' command starts a series of 'NumFrames' frames with the exposure time 'ExpTime' and the delay time 'DelayTime' between frames. Both 'time' parameters are in seconds. The data are stored under 'SavingPath' with the file name constructed by 'FileNamestart' followed by a 4 digit frame number. The frame numbering starts with 'FirstFrame' and the images are stored as '*.spe' files.

If 'NumFrames' is smaller or equal to 256 and the 'DelayTime' is set to zero than the data are stored in multi image files. This has the advantage that an additional overhead between frames of ~0.6seconds can be prevented. The time between frames for a full frame exposure can be estimated as: Readout time (1.8s) + 'ExpTime' + 'DelayTime' + Overhead (0.6s).

3.4. PI-Pixis

The Pixis detector (Princeton Instruments) is a new generation of CCD detector from Princeton Instruments having mainly the same as in LCX CCD chip installed (pixel size 20x20μm^2 , 1340(h)x1300(v) px^2). The detector requires no water cooling circle, otherwise the installation procedure is same as in the LCX case.

3.5. Andor iKon-L

The Andor iKon-L is a high resolution CCD camera with chip area of 2048×2048 px^2 and pixel size of 13.5×13.5 μm^2 . Readout frequency up to 5 MHz is possible with this detector. In order to operate the peltier-cooled chip working at -65 °C , the camera requires water cooling cycle (normal setting of 15 °C). The Andor camera acquires images (tif, edf) with 16-bit resolution.

4. Recovery steps in case of computer failures

General information

The P10 beamline is controlled by a Linux based computing system. Each area of P10 has its own control computer. These computers are called:

1) Optics hutch: **haspp10opt**
2) Experimental hutch #1: **haspp10e1**
3) Experimental hutch #2: **haspp10e2**

Each of these computers controls hardware via an independent VME controller and an independent Tango Device Manager (called by 'astor').

Additionally the P10 beamline has 2 more control computers:

1) P10 E-Lab: haspp10lab
2) Vacuum interlock PC: hasp10vil

Some possible scenarios

The users will use ONLINE to control their experiments most of the time. So if ONLINE hangs than it should be restarted first. In general the instruction manuals to ONLINE and other experimental control software can be found on the web pages of FS-EC under computing manuals:
http://hasylab.desy.de/infrastructure/experiment_control/index_eng.html

Terminating 'Online'

To kill 'Online' open a new terminal and type:

> ps a | grep gra_main

This command searches for the process identity ('*pid*') of the ONLINE process. This process identity is listed in the first column. Try to kill the ONLINE process by typing: kill -1 *pid*
If the process persists use the more brutal command: kill -9 *pid*

After ONLINE has been terminated, it can be restarted by switching to the ONLINE data directory (normally something like: '/data/YEAR+CYCLE/DATE/' and typing: 'online -tki').

Terminating Tango Servers

Please read the description for the ASTOR Tango Device Manager. It explains how Tango Servers are killed and restarted.

Generally, one can try 'Stop All' (see Fig. 16), wait until all servers shut down (turn 'red') and then 'Start All' (it takes several minutes until all servers get on, i.e. 'green').

Fig. 16: Dialog window of the Astor Tango server manager.

Note:

If the above steps did not solve the problems then it might be necessary to reboot the VME and/or the control computers. However, the previous steps should always be tried first!

Rebooting the VME crate

In order to restart the VME crate, the Tango Servers of all, to the VME connected, devices should be stopped. Looking at this screen shot (Fig. 16), the 'Stop All' button should be used. It is necessary to wait until all green indicators are turned red, before proceeding to restart the VME. The VME is stopped by turning the 'power off' of the fan unit underneath the VME (see Fig. 17). After a 10 second waiting time, the VME power can be switched back on and the Tango Server can be restarted by using the 'Start All' button.

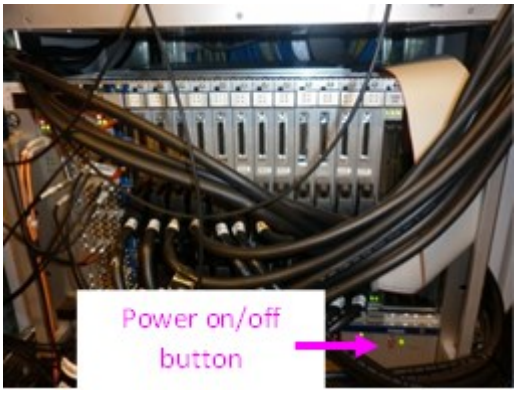


Fig. 17: View of the VME crate.

Restarting the control computer

If the control computer is frozen, then it might need to be reset. Before using the hardware reset switch, one can try to use another control computer of the P10 beamline to 'ssh' into the problematic control computer, e.g. opening a new terminal and typing:

> ssh haspp10opt (e1 or e2)

The shutdown command would be:

> sudo /sbin/restart -P now

If this doesn't work the square 'reset' button under the front cover should be used. Hopefully the computer comes up normally and the user can login as 'p10user'. The password should have been provided at the start of the beamtime.

Restoring the control computer

After the control computer is restarted and the user logged back on as 'p10user' it is necessary to recover the session. The p10 control computer has in the standard configuration six desktop panels which can be accessed from the taskbar located on the bottom of the screen. The six panels are called: 'Online', 'Optics', 'X-Ray Eye', 'Interlock', 'Macros' and 'Other'.

The Online panel

In this panel the ONLINE session and the Tango Device Manager for EH1 & EH2 should run. It is recommended to open three terminals. The first terminal should just start a Tango Device Manager. The command is: 'astor &'. The second terminal should connect to the other control computer via ssh. The command is: 'ssh haspp10e1' or 'ssh haspp10e2' depending on which control hutch is occupied. The Tango Device Manager is called again by 'astor &'. The third terminal should be used to call ONLINE. The user should first change to the data collection directory (the standard directory would be of the form '/data/YEAR+CYCLE/DATE/'). ONLINE is started then by typing 'online -tki'.

The Optics panel

This panel should be used to control components connected to the optics control computer 'haspp10opt'. Again the user should open two terminals and use both to ssh to the optics computer via: 'ssh haspp10opt'. The first terminal should be used to start the Tango Device Manager via 'astor &' and the second terminal should be used to open 'Jive' via 'jive &'. From the Jive panel the user should open the Undulator control window. This can be done by opening the tree 'Petra3Undulator', 'p10' and 'Petra3Undulator' till the 'p10/undulator/1' device is found. A right click on 'p10/undulator/1' opens a context menu and the selection 'Monitor Device' opens the undulator control window.

The Interlock panel

This panel should be used to start Firefox browser. The homepage of Firefox is set to the following tabs:

Tab 1: Interlock control system
Tab 2: Vacuum interlock control system
Tab 3: PETRA III infoscreen
Tab 4: PETRA III machine log book

The X-Ray Eye panel

This panel is used to start the 'X-ray Eye' beam camera. The software for the ‘X-ray Eye’ is installed on the optics control computer so it is necessary to open a terminal and to use 'ssh haspp10opt'. The ‘X-ray Eye’ software is started by typing 'SampleViewer' (case sensitive!). This opens the control window and by clicking on the 'Eye' symbol the camera display window is opened and by clicking on the 'Wrench' symbol the settings window is opened.
The other panels are currently not used.

5. Commands and macros at P10

To start the Online GUI interface (PerlTk interface) one has to launch

[p10user@hasp10e2]$ online –tki

from a Linux terminal on control PC (example of EH2).

Once the ONLINE session is started the control commands can be executed from a command line of GUI. In following the commonly used macro-commands (syntax emulating SPEC commands) are listed.

Counting commands:

> count exptime	- execute acquisition by selected counters for 'exptime' in seconds;
> diode in	- move photodiode (inside flight tube) in the beam;
> diode out	- extract photodiode from the beam;
> refdiode in	- move reference photodiode (after the sample) in the beam;
> refdiode out	- extract reference diode (after the sample) from the beam;
> udiode in	- move USAXS photodiode (EH1) in the beam;
> udiode out	- extract USAXS photodiode from the beam;

Interlock shutter control macros:

Here 'ehN' means either 'eh1' or 'eh2' for experimental hutch 1 or 2, respectively.

> ish ehN open	- open interlock shutter (usually after the interlock is set by searching the hutch);
> ish ehN close	- close interlock shutter without breaking the door interlock;
> ish ehN break	- close interlock shutter and break the door interlock. Before entering the hutch be sure the door lights are switched off;

Commands to control slow and fast shutters:

> osh	- open fast shutter;

> csh - close fast shutter;

> oss - open slow shutter;

> css - close slow shutter;

> fastshutter in - insert fast shutter in the beam path;

> fastshutter out - extract fast shutter from the beam path;

Absorber commands:

> abs? - show currently used absorber set; all possible absorber combinations are also displayed;

> abs n - insert absorber in the beam, n is an integer number from 0 to 192 (possible number of 25 um thick Si plates/ Au foils: (0, 1, 2, 3, 4, 6, 8, 9, 12, 16, 18, 24, 32, 33, 36, 48, 64, 66, 72, 96, 128, 129, 132, 144, 192));

> abs 0 - move absorbers out (no absorber in the beam, use with care!);

Caution: When working with 2D detectors, be sure to have fastshutter inserted in the beam ('>fastshutter in')!

Commands to move/scan motors:

> wm mot1 mot2 mot3 … - display current position of a specific motor (can be applied to up to 6 motors simultaneously;

> mva mot1 x1 - move absolute motor 'mot1' to position 'x1'

> mva mot1 x1 mot2 x2 mot3 x3 ... - Move absolute a maximum number of 6 motors simultaneously;

> mvr mot1 x1 - move relative motor 'mot1' to position 'x1'

> mvr mot1 x1 mot2 x2 mot3 x3 ... - Move relative a maximum number of 6 motors simultaneously;

> whereslit n - display the positions of blades of JJ slit 'n'. n=1, 2 or 3 correspond to JJ1, JJ2 (pair of collimating slits before a sample) and JJ3 ('detector slits' in front of CyberStar/APD);

> moveslit n hgap hcenter vgap vcenter - move JJ slit 'n' (n=1, 2 or 3) to horizontal gap 'hgap', horizontal center 'hcenter', vertical gap

to ’vgap’ and vertical center of ‘vcenter’; all target values are in [mm];

> ascan mot1 x1 x2 npoints ctime

- absolute scan of a motor ‘mot1’ from position ‘x1’ to position ‘x2’ with number of points ‘npoints’ and exposure ‘ctime’;

> dscan mot1 x1 x2 npoints ctime

- relative scan of a motor ‘mot1’ from position ‘x1’ to position ‘x2’ with number of points ‘npoints’ and exposure ‘ctime’;

> amesh mot1 x1 x2 NP1 mot2 y1 y2 NP2 ctime

- absolute mesh scan of motor ‘mot1’ in a range from ‘x1’ to ‘x2’ with ‘NP1’ points at different positions of motor ‘mot2’ in a range from ‘y1’ to ‘y2’ with ‘NP2’ points at exposure time ‘ctime’;

> dmesh mot1 x1 x2 NP1 mot2 y1 y2 NP2 ctime

- relative mesh scan ;

In case the motor movement/scan has been stopped (by pressing ‘Stop’ button in ONLINE GUI), for restoring the ability to move motors, one needs to execute the command :

> reset_stop

Commands to move the selected detector in its working position:

> det cbs - move in the point detector (CyberStar/APD);

> det xray - move in the ‘X-ray Eye’ camera;

> det max22 - move in the MAXIPIX (2x2) detector;

> det lcx - move in the LCX CCD detector;

> det pixis - move in the Pixis CCD detector;

> det p300 - macro command to move in the PILATUS 300K detector;

In the case when *count* command (for monitoring beam intensity with the flight tube diode, *diode in*;) is used after previous use of 2D detector (LCX/Pixis , Maxipix, or Pilatus) , one has to take over fastshutter control by applying a macro command(s)

> ccd1off # to take over from LCX/Pixis detector;

> ccd2off # to take over from Maxipix detector;

> ccd3off # to take over from Pilatus detector;

Commands for 2D detector acquisition:

Before starting acquisition with 2D detector one has to setup the detector by

> *det*setup "/*filedir*/" "*filename_*" *startnum* ;

where
'*det*' stands for 'p300' (Pilatus300K detector), 'max22' (Maxipix detector), 'lcx' (LCX detector) or 'pixis' (Pixis detector);
'*filedir*' is the directory where the data will be stored;
'*filename*' is the file root name;
'*startnum*' is the number of 1st frame.

> *det*take exptime - acquire a single frame with exposure time 'exptime' in seconds;

> *det*series numframes exptime (delaytime) - acquire a series of 'numframes' frames with with exposure time 'exptime' and optional delay time in seconds;

Mesh scans with 2D detectors:

> *det*amesh mot1 x1 x2 NP1 mot2 y1 y2 NP2 nframes ctime
- absolute mesh scan with two motors and acquisition by 2D detector;

> *det*dmesh mot1 x1 x2 NP1 mot2 y1 y2 NP2 nframes ctime
- relative mesh scan with two motors and acquisition by 2D detector;

Operating the CRL transfocator:

> wm ehcrl - display the currently used CRL combination;

> mva ehcrl <*combi*> - insert the lens combination *combi* in the beam (read also §2.7);

> mva ehcrl 0 - extract CRLs from the beam path;

> mva ehcrl 4095 - insert all CRLs in the beam path (for testing only);

> mva ecrlx2 *dist* - move absolute the CRL transfocator along the beam to the position *dist* in [mm];

DAC control:

> p10dac *dacchannel voltage* - set voltage in [V] to a selected DAC channel (i.e. e2_dac03);

Lakeshore temperature controller commands:

> lake on; - start LakeShore controller;

> lake off; - stop LakeShore controller;

> lake pow <P>; - set heater power level;

Possible values are 0, 1, 2, 3, 4, 5 which correspond to heater power of 10 mW, 100 mW, 1 W, 10 W, 92 W;

> lake T ?; - show actual temperature ;

> lake T ? A K; - show actual temperature of channel 'A' in [K];

> lake T ? B C; - show actual temperature of channel 'B' in [C°];

> lake setp <T>; - set setpoint temperature;

> lake PID <P> <I> <D> - set PID parameters of temperature control (see LakeShore manual);

When using sample inserts equipped with Peltier element, one has to switch on the Kepko current supply and set correct DAC voltage.

For heating above 100 C° one has to apply command :

> p10dac e2_dac02 -2 ; # this command applies -2V voltage to DAC channel e2_dac02, which converts to -1.6 A current setting of Kepko supply.

For RT measurement and cooling down below RT one has to apply following DAC voltages :

> p10dac e2_dac02 0.5 ; # for T range 285 – 305 K

> p10dac e2_dac02 1 ; # for T range 270 – 290 K

> p10dac e2_dac02 0 ; # for T range 300 – 350 K

Notes, comments: